1973-06

The effect of probability preferences in gambling situations.

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http://hdl.handle.net/10945/16580

THE EFFECT OF PROBABILITY PREFERENCES IN GAMBLING SITUATIONS

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THESIS

THE EFFECT OF PROBABILITY PREFERENCES
IN
GAMBLING SITUATIONS

by

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June 1973

The Effect of Probability Preferences in Gambling Situations

by

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
June 1973

ABSTRACT

An experiment was run to examine the main factors determining choices among bets in gambling situations. In the first experiment, where all the bets had an equal expected value, a specific set of preferences among probabilities was observed. The most important of these is a preference for a 4/8 probability of winning and an avoidance of a 6/8 probability of winning. In the second experiment, where all bets had differing expected values, it was shown that both preferences for bets with higher expected values and preferences among probabilities influence subjects' choices.

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I. INTRODUCTION

People in gambling situations do not make choices in such a way to maximize their expected winnings or minimize their expected losses, although there is reason to assume that these are their goals. Several theories have been offered to explain these facts, and experiments have been done to test the theories.

A. ASSESSMENT OF RISK TAKING BEHAVIOR

Most dictionary definitions of risk center around the phrase "chance of loss." Accordingly, the magnitudes of both probabilities and losses enter into the determination of the amount of risk which a given course of action entails.

A number of investigators have been concerned with willingness to gamble on ability tests as reflective of general risk taking tendencies. When Cronbach (1946) discussed the types of response sets that contaminate test scores, he mentioned several that have been of particular interest to researchers seeking objective measures of risk taking. These are: (1) the tendency to guess on a test item when uncertain about the answer rather than omit it (Cronbach labeled this the gambling responses set); (2) the tendency to include many items in a given category when no limit is imposed (the inclusiveness set); (3) the tendency to answer rapidly on time tests, attempting to compensate for committing a greater number of errors by completing more items (the speed vs. accuracy set).

Other potential risk-taking indices include measures of extremity of judgment in situations where greater extremity affords the possibility of a greater magnitude of error and judgmental confidence or certainty. This might be indicative of an individual's biases in perceiving probabilities of success and failure. Brim and Hoff (1957) investigated the Desire for Certainty Test in which subjects were asked to complete sentences of the form "The chances that such-and-such an event will occur are about --- in 100." After making his probability estimate the subject rated his confidence in that estimate. Scores obtained were the mean confidence rating and mean deviation from the most conservative probability estimate (which is 50%). Wallach and Kogan (1959) studied sex differences on the Desire for Certainty Test. They found that for items in which persons were anything less than quite sure, men's probability estimates were more extreme than those of women. For items on which subjects were very sure, women's probability estimates were more extreme. They concluded that women were highly certain less frequently than men, but when they were very certain they were willing to take large risks.

More indices of risk-taking behavior are probability and variance preference measures (probability preferences being the subject of my experiment). Edwards (1954 b, 1954 d) pioneered in the study of preferences among gambles differing in probability of winning and losing. He observed that subjects had definite preferences for betting at some probability levels rather than at others.

Coombs and Pruitt (1960) noted that a bet with probability P to win A dollars and probability Q to win B dollars can be viewed as a probability distribution over outcomes of money whose mean or expected value is $P(A) + Q(B)$, and whose variance is $PQ(A-B)^2$. Coombs and Pruitt argued that

in addition to probability preferences, variance preferences are indicative of an individual's utility for risk. The variance of a bet reflects the amount of deviation of its possible outcomes from the average amount of money to be obtained by playing the bet. For example, a bet offering even odds to win or lose five dollars has a larger variance than a bet offering even odds to win or lose one dollar, although both have an expected value of zero dollars.

Coombs and Pruitt (1960) had subjects choose among pairs of zero expected value bets differing in probability of winning but with variance held constant and vice versa. They found sizeable individual differences in probability and variance preferences. Variance preferences were less stable than probability preferences and in general, subjects preferred greater variance for bets which contained their favorite probabilities.

It should be noted that for bets with two outcomes and zero expected value, such as those used by Coombs and Pruitt, alternatives with high probabilities of winning carry with them the possibility of a large loss. Similarly, though long shot bets afford greater opportunities to lose, the amount of money that may be lost is relatively small. Therefore, there is no unequivocal hypothesis concerning the relation between probability preferences among these bets and high risk taking. The magnitude of risk which persons perceive in these bets is an open question.

Additional studies support the notion that variance preferences exist and are consistent for a given individual within a particular risk-taking task.

Atkinson (1957) has stimulated much work related to the study of probability preferences. The basis for Atkinson's risk-taking model came from the relationship that McClelland (1956 b, 1958) found between need for

achievement and preference for moderate probabilities of success in ring toss, level of aspiration, and vocation choice. The model involves six variables: the subjective probability (i.e., expectancy) of success (P_s), the subjective probability of failure (P_f), the incentive value of success (I_s), the (negative) incentive value of failure (I_f), the achievement motive (M_s), and the motive to avoid failure (M_f). Incentive values and subjective probabilities are assumed to be inversely and linearly related. The variables are combined multiplicatively in the following equation: Resultant Motivation = (M_s x P_s x I_s) + (M_f x P_f x $-I_f$). The Resultant Motivation function has a maximum at P_s = 0.5 if M_s is greater than M_f, and minimum at P_s = 0.5 if M_f is greater than M_s. Thus Atkinson predicts that individuals in whom M_s is greater than M_f will prefer tasks with intermediate P_s, while persons dominated by M_f will prefer tasks in which P_s is extremely high or low.

Atkinson found support for the model from the fact that subjects with high M_s preferred to shoot from moderately difficult distances in a shuffle-board game while high M_f persons preferred the extremely easy or difficult distances. He also obtained probability preferences among bets in a make-believe gambling situation. Subjects were asked to make choices such as "Would you prefer odds of 1/6 to win $18.00 or 4/6 to win $4.50?" Expected value was held constant but variance decreased monotonically as probability of winning increased. Subjects with low M_s preferred extreme probabilities but the preferences of subjects with high M_s were evenly distributed across all probabilities. Scodel, Minas, and Ratoosh (1959) related probability preferences in a real gambling situation to achievement motivation and other selected personality variables. Variance was not controlled. Subjects preferring intermediate probabilities of success and intermediate payoffs scored highest on M_s, supporting Atkinson's theory.

Risk taking behavior appears to be multidimensional in nature. It has subjective components and is susceptible to a variety of other influences. Therefore, the results of the following experiment should be viewed in this light. My experiment will identify several phenomena involved in preferences among bets and is not meant to supply conclusive evidence that these preferences are in fact valid over a large section of the population.

II. EXPERIMENT

The decisions people make in gambling situations are psychologically interesting because they are motivated human responses and because they are primarily controlled by simple numerical properties of the stimulus situation. In any situation in which a person must decide whether or not to bet on the occurrence of a future event, two sets of variables will probably be crucial in controlling his behavior: the probability of winning or losing, and the amounts which can be won or lost. If the amount of money (or any other measurable commodity) which can change hands for each possible outcome of a bet is multiplied by the probability of that outcome, the sum of these products over all possible outcomes is called the expected value (EV) of the bet. The expected value is the amount the gambler should expect to win (or lose) on each play of the bet. If a bet has a positive expected value, the gambler will in the long run profit by taking it. If it has a negative expected value, he will in the long run lose by taking it. If it has an expected value of zero, he is just as likely to win as to lose in the long run. The following two experiments were designed to identify variables which determine choices among bets which are constant in expected value (experiment I) and which differ from one another in expected value (experiment II).

A. CONSTANT EXPECTED VALUE (CEV) EXPERIMENT

The gambling in this experiment was done with seven decks of cards. Each deck was separated into suits, and eight cards of each suit (A, 2, 3, 4, 5, 6, 7, or 8) were put in 28 separate piles of eight cards each. Each subject was assured that the top card of each pile was equally likely to be an A, 2, 3, 4, 5, 6, 7, or 8. During the experiment no subject expressed doubts about the honesty of the game.

1. Bets

A set of eight bets was used. Each bet in the group of eight has a positive expected value of $.10 (see Table I).

Each bet was paired with all the others and this procedure produced 28 pairs. Each pair of bets was typed on a 3 X 5 card and the 3 X 5 cards were shuffled. This deck of 3 X 5 cards, each with a pair of bets typed on it, the 28 piles of eight cards each, and plenty of poker chips made up the experimental apparatus.

2. Subjects

The subjects were 12 Monterey Peninsula College students. Four of the 12 had reservations about gambling and were not tested; another two of the subjects failed to meet their appointed time; so the total number of subjects was six.

3. Procedure

The subjects were shown the 28 stacks of cards and told the nature of the experiment. They were informed that they might lose some of their own money. They were also told that once they started the experiment, they

TABLE I

BETS USED IN EXPERIMENT I

1. If top card is 4, win 1.00; otherwise lose .02.
2. If top card is A or 7, win .50; otherwise lose .03.
3. If top card is 2, 4, 6, win .33; otherwise lose .04.
4. If top card is 2, 4, 7, 8, win .25; otherwise lose .05.
5. If top card is 2, 3, 5, 7, 8, win .20; otherwise lose .07.
6. If top card is anything <u>but</u> 3 or 6, win .17; otherwise lose .10.
7. If top card is anything <u>but</u> 5, win .14; otherwise lose .20.
8. If top card is anything, win .10.

would be required to finish it, regardless of whether they won or lost. They were also told that the experiment would be biased in their favor to the extent that they were given a dollar for the session in which no real gambling took place (the just imagine session).

4. Just Imagine Session

Each subject looked at each of the 28 pairs of bets and reported which bet he would prefer if he were really gambling but no cards were used and no money or chips changed hands.

5. Real Gambling Session

Each subject was given $10.00 worth of poker chips at the beginning of the session. He was required to keep these chips in a box sufficiently small so that it was not easy for him to estimate during the course of the experiment how many chips he had. The subjects were discouraged from counting their chips after verifying that the original count was correct, but if one insisted, as occasionally happened, he was permitted to do so. After the subject gave his preference for one of the bets typed on a card, he overturned the top card of one of the 28 piles. If he won, he was immediately given his winnings in chips; if he lost, he immediately paid in chips. After the choice and its outcome were recorded, the subject proceeded to the next pair of bets and again made his choice. They did not have the option to refuse to gamble on a particular set of bets. At the end of the session the subjects' chips were counted and the excess over $10.00 was considered his winnings. If the sum was less than $10.00, the difference was considered his losses (this never happened, incidentally).

6. Results

The data analysis performed are those which are important for understanding what variables systematically influenced decisions. The simplest way to treat the data on paired comparisons was to count the choices of each bet over all the other bets with which it was compared. These counts were combined for all subjects. Figure I and Table II present the results of the bets. The relative preference is the number of times each bet was preferred to the seven others with which it was compared, divided by the total number of comparisons.

TABLE II

RESULTS FOR THE CONSTANT EV EXPERIMENT

Probability	Just Imagine	Real Gambling
1/8	.048	.114
2/8	.054	.125
3/8	.119	.137
4/8	.161	.184
5/8	.149	.143
6/8	.137	.089
7/8	.155	.101
8/8	.178	.107

Each number appearing in the table is an index of relative preference for a bet over all others.

The significant features of this graph are the peak at 4/8, the valley at 6/8, and the change in slope from just imagining to real gambling sessions. The peak at 4/8 probably represents a specific preference for the 4/8 probability; and the valley at 6/8 probably represents a specific aversion for the 6/8 probability. The slope change probably represents an increase in the willingness to take chances (long shots rather than short shots) in real gambling situations.

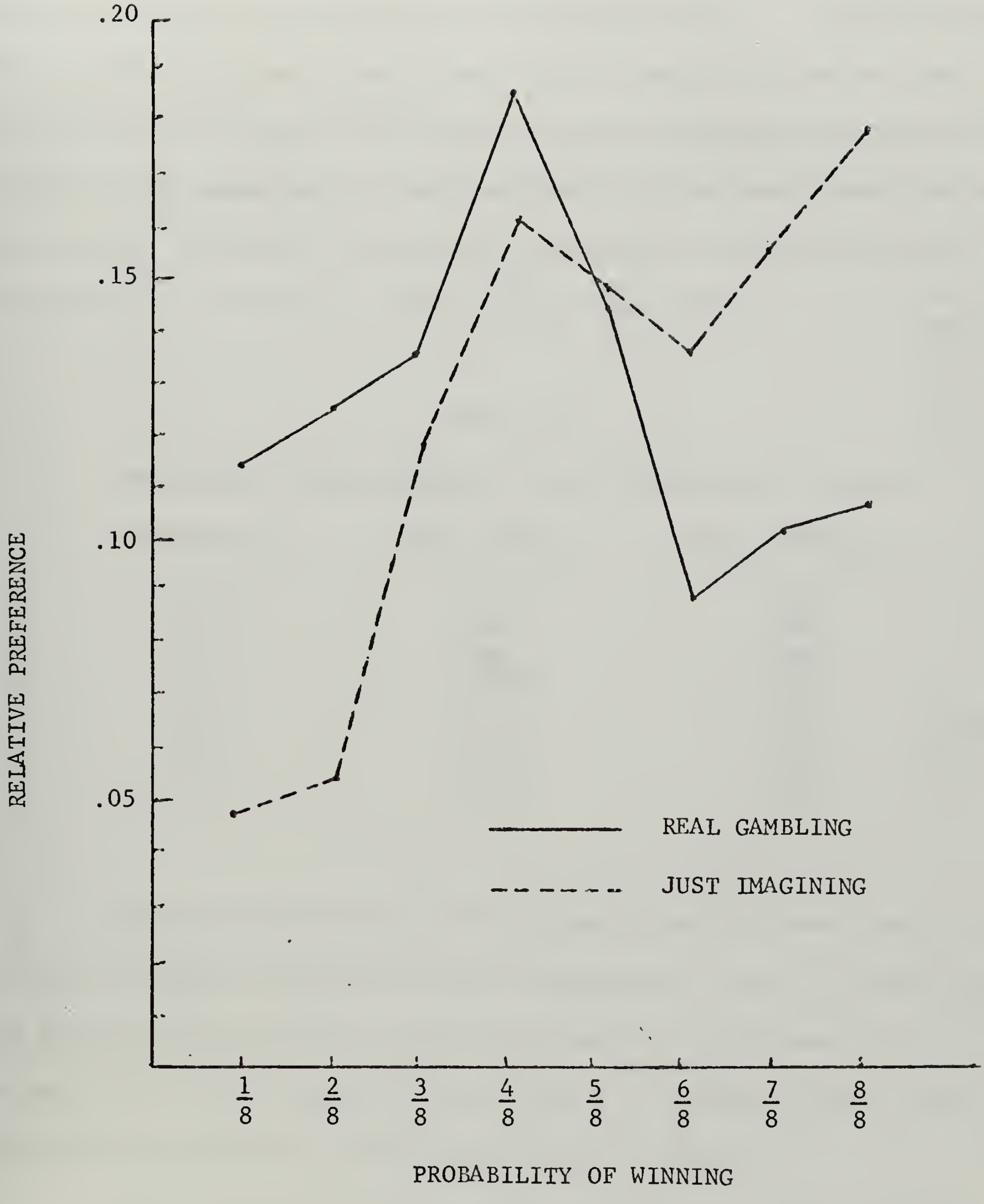

Figure 1 - Results of Experiment I

The general change in willingness to take chances can be removed in a rough way by the graphical device of passing a regression line through each set of points and plotting the deviations from it. Figure II and Table III show the deviation of each point from its regression line. Once the difference in slope due to the different experimental conditions is removed (just imagining vs. real gambling), the agreement among the residual curves which represents the specific pattern of preferences for some probabilities over others is much greater than before.

TABLE III

DEVIATIONS FROM REGRESSION LINES FOR CONSTANT EV BETS

Probability	Just Imagine	Real Gambling
1/8	-.022	-.029
2/8	-.029	-.013
3/8	+.020	+.003
4/8	+.041	+.053
5/8	+.012	+.014
6/8	-.022	-.035
7/8	-.015	-.020
8/8	-.010	+.002

One of the advantages of the method of paired comparisons is that it does not force the subjects to be consistent. One of the most interesting kinds of inconsistency in this experiment is found when bet A is preferred to bet B, B is preferred to C, and C is preferred to A. Such a set of preferences will be called an "inconsistent triad."

Counts were made of all inconsistent triads. Kendall (1948) offers a statistic based on the number of inconsistent triads called the coefficient of consistence, which equals one minus the ratio of the number of inconsistent triads found to the maximum number of inconsistent triads possible. This coefficient, of course, varies from one to zero, with one

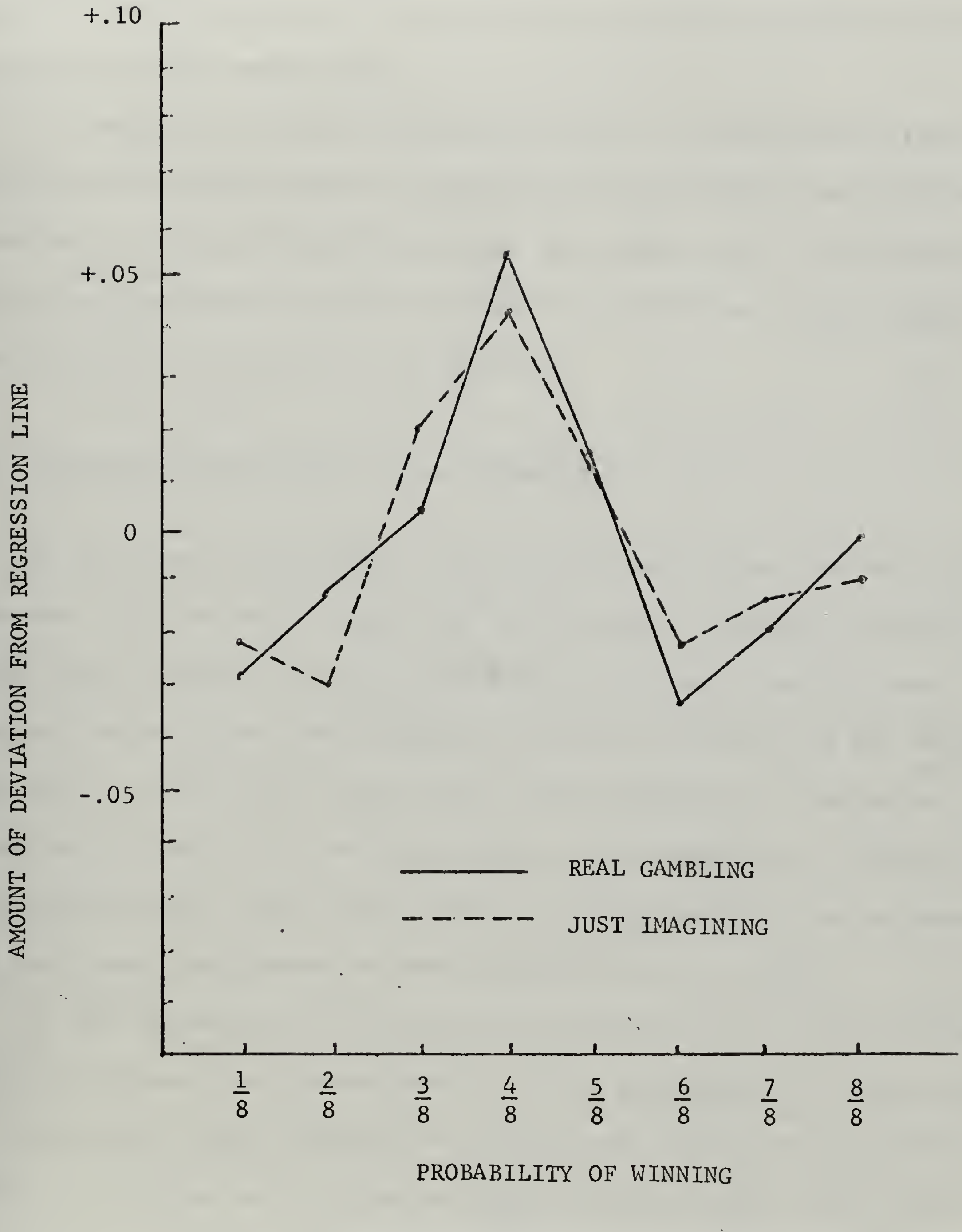

Figure 2 - Deviations From Regression Lines for Constant EV Bets

representing complete consistency. The mean coefficients of consistency in this experiment were 0.76 for the just-imagine portion and 0.84 for the real gambling portion. The consistency is fairly high and increased as the experiment progressed.

Analysis was made of the bets involved in inconsistent triads. The only interesting result is that the 4/8 probability of winning was involved in substantially fewer triads than other bets. This finding is of course consistent with the fact that the 4/8 bet was usually preferred to all others with which it was compared.

B. DIFFERING EXPECTED VALUE (DEV) EXPERIMENT

In the previous experiment, every choice was between two bets with the same expected value. Some bets were markedly preferred to others, even though, since all choices were between bets which had the same expected value, there was no objective reason for preferring any bet to any other. For example, those with a 4/8 probability of winning were especially often chosen, and those with a 6/8 probability of winning were especially seldom chosen. The results were attributed to the existence of consistent preferences for some probabilities over others.

In this experiment, every choice was between two bets with different expected values. What should happen in this experiment? If such phenomena as preferences among probabilities are ignored, the writer expected the subjects to chose the bet with the higher expected value. The failure of subjects to follow this simple expected value maximization strategy would suggest that something other than expected values was influencing his behavior, but would not show what. In order to show that probability preferences were influencing his behavior, it would be desirable to be able

to use previous knowledge of probability preferences to predict deviations from simple expected value maximization. I will examine such deviations and see whether they can be predicted from probability preferences.

The gambling in this experiment was done with the same seven decks of cards separated into 28 separate piles of eight cards each. Again each subject was assured that the top card of each pile was equally likely to be an A, 2, 3, 4, 5, 6, 7, or 8.

1. Bets

Again a set of eight bets was used; only this time, bets that differed from one another in expected value were used. Table IV reproduces these bets.

Two criteria were followed in making up the differing expected value bets in Table IV. First a bet with a higher probability of winning was required to pay off less than a bet with a lower probability of winning, and no bet could involve administratively unreasonable amounts of money. Secondly, an attempt was made to choose bets with expected values such that consistent preference of the bet with the higher expected value would result in a rank ordering of the bets inverse to that found in Experiment I. Unfortunately, these requirements turned out to be inconsistent with one another. For example, since the most preferred bet in Experiment I was the 4/8 bet, the writer chose the 4/8 bet in Experiment II to have the lowest expected value, which is exactly what he wanted. However, it was not possible to arrange all the bets in such a manner and still satisfy the first criterion. Therefore, it was necessary to slightly compromise the second. Nevertheless, this compromise should not have a significant effect on the predictions of deviations from expected value maximization.

TABLE IV

BETS USED IN EXPERIMENT II

1. If the top card is a 4, win 3.00; otherwise lose .14 (EV = .25 per play).

2. If the top card is an A or 7, win 1.45; otherwise lose .16 (EV = .24 per play).

3. If the top card is a 2, 4, or 6, win .87; otherwise lose .17 (EV = .22 per play).

4. If the top card is a 2, 4, 7, or 8, win .60; otherwise lose .20 (EV = .20 per play).

5. If the top card is a 2, 3, 5, 7, or 8, win .55; otherwise lose .29 (EV = .23 per play).

6. If the top card is anything <u>but</u> 3 or 6, win .53; otherwise lose .56 (EV = .26 per play).

7. If the top card is anything <u>but</u> 5, win .50; otherwise lose 1.12 (EV = .29 per play).

8. If the top card is anything, win .28 (EV = .28 per play).

The differing expected value bets were also typed on 3 X 5 cards in pairs, so there were 28 differing expected value 3 X 5 cards. The apparatus used was exactly the same as Experiment I (i.e. the 28 piles of eight cards each and plenty of poker chips).

2. Subjects

The subjects were the same six male students from Monterey Peninsula College. This sample is hardly representative of any population in general so generalizations of the findings must be made with caution.

3. Procedure

The procedure was the same as in the real gambling session of Experiment I. The subjects were told that they could win or lose plenty of money, and that if they lost, they would have to pay out of their own money, but that the situation was biased in their favor to the extent of one dollar a session--each subject was given one dollar more in chips at the beginning of the session than he was required to return at the end. The subjects were run individually and never met one another during the session.

4. Results

Figure III and Table V show the results for the differing expected value bets, compared with the constant expected value bets of Experiment I. The Y-axis is the index of relative preference. Again, it is computed by counting the total number of choices by all subjects of a bet over all others with which it was compared and dividing by the total number of choices made by all subjects on all bets. The maximum value this number can have for any bet is 0.25, which can occur if everyone chooses the bet

every time he has a chance. The minimum is 0.00, which can occur only if the bet is never chosen. The X-axis represents the probability of winning. These probabilities are arranged in order of decreasing expected value for the differing expected value bets, so that consistent choice of the bet with the higher expected value would result in the downward sloping straight line shown.

TABLE V

RELATIVE PREFERENCE VALUES FOR DIFFERING EV EXPERIMENT COMPARED WITH THOSE FROM THE CONSTANT EV EXPERIMENT

Probability	Constant EV	Differing EV
1/8	.114	.161
2/8	.125	.125
3/8	.137	.101
4/8	.184	.077
5/8	.143	.113
6/8	.089	.137
7/8	.101	.179
8/8	.107	.107

The solid line shows the results for the Differing EV bets; the dashed line shows the results from the Constant EV bets from Experiment I; the dot-and-dashed line shows the results which would have been obtained if all subjects had followed a strategy of expected value maximization on the Differing EV bets; and the dot-dot-dashed line shows the results which would have been obtained in the Constant EV experiment if probability preferences had not influenced the subjects' choices. Clearly, for the Differing EV bets, there is a general trend downward from left to right, as the strategy of maximizing expected value would require, but there are marked deviations from that strategy.

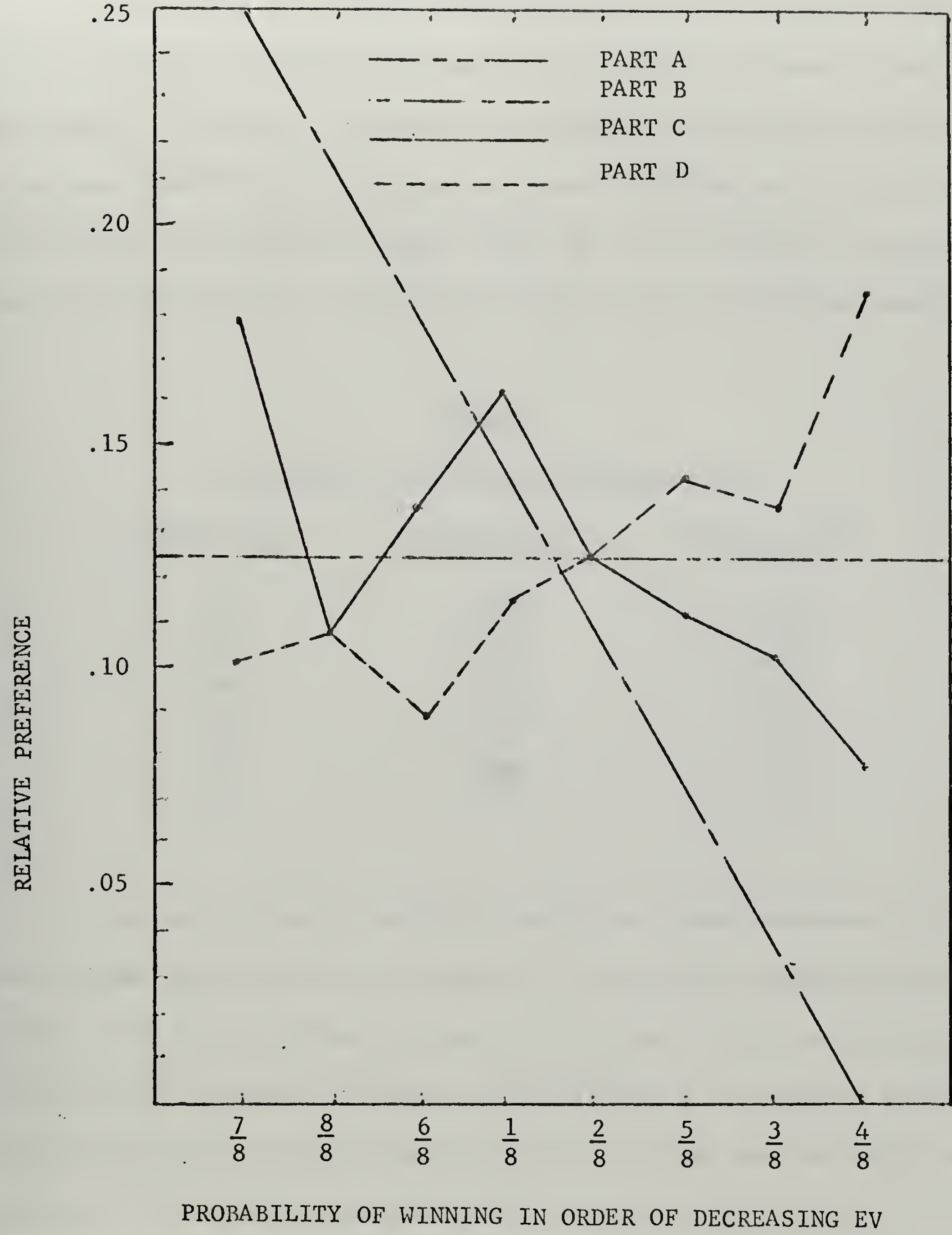

Figure 3 - Results of Experiment II

Part A - Curve of CEV Maximization
Part B - Curve of DEV Maximization
Part C - Differing EV Results
Part D - Constant EV Results

Also, there is evidence that the deviations from maximization of expected value are related to probability preferences found in the first experiment. In order to illustrate this point, tabulations were made of deviations from the curve of expected value maximization for the Constant EV experiment (the dot-dot-dashed line) and the Differing EV experiment (the dot-dashed line). Table VI and Figure IV present these tabulations.

TABLE VI

DEVIATIONS FROM EV MAXIMIZATION CURVES

Probability	Constant EV	Differing EV
1/8	-.011	+.019
2/8	+.000	+.018
3/8	+.012	+.066
4/8	+.059	+.077
5/8	+.018	+.042
6/8	-.036	-.041
7/8	-.024	-.071
8/8	-.018	-.107

Spearman devised a suitable coefficient which measures the correlation between the two curves of Figure IV. This rank correlation coefficient is .857 which is significant beyond the .995 level in a one-tailed t-test. In other words, subjects' choices were influenced by expected value maximization, but the deviations from this strategy can partially be attributed to probability preferences.

It is clear from the results that subjects do not consistently prefer bets with higher expected values to bets with lower expected values. Part of the variation from this simple strategy could have been predicted by probability preferences.

In these bets, the probability preferences and expected value differences were strongly in opposition with each other; one or the other

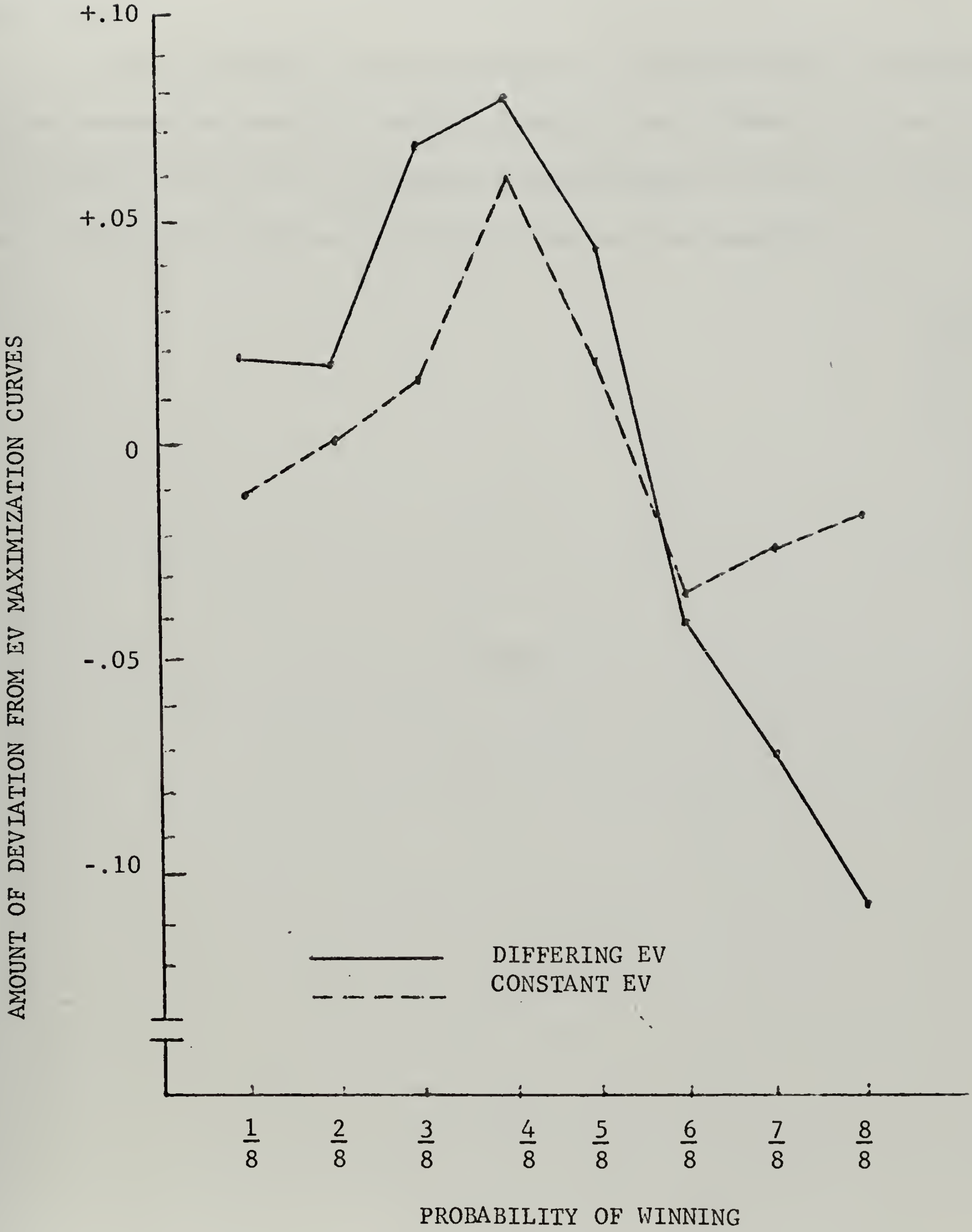

Figure 4 - Deviations From EV Maximization Curves

had to emerge as the major determinant of choices, but in this case the expected value differences turned out to be as important as probability preferences.

It is reasonable to suppose that as the difference in expected value between two bets, of which the subject must choose one, increases, it becomes more and more important in determining the subject's choice, and probability preferences therefore become less important.

III. CONCLUSIONS AND SUMMARY

The results of Experiment I showed that there are two main factors determining choices among bets of equal expected value. The first is a general tendency to prefer or avoid long shots (bets with low probability of winning or losing and a large amount of win or loss), depending on experimental conditions. For instance subjects prefer long shots much more when gambling for real money than when just imagining what they would do if they were gambling. The second determinant for choices is a set of specific probabilities. The most important of these are a preference for a 4/8 probability of winning and an avoidance of a 6/8 probability of winning.

Subjects made choices in such a fashion that inconsistent triads of choices appeared a little less than one-fourth the number of times they could have appeared, and the number of inconsistent triads decreased as the experiment progressed.

Experiment II was designed to find out what subjects would do when required to choose between bets with different expected values. The results showed that both preferences for bets with higher expected values and preferences among probabilities influence subjects' choices. The former factor was dominant in those bets with large relative differences in expected value.

It is unfortunate that probability preferences and differences in expected value both determine decisions in gambling situations. If expected value were the only important variable, the wonderful mathematical model provided by utility theory would predict such decisions. Even so, it might

eventually be possible to develop subjective scales of probability (which would allow for probability preferences). Then the mathematical model could perhaps be used with these scales to predict risky decisions. The high correlation between expected value and probability preference differences in this experiment suggest that an additive model, taking into account an expected value factor and a probability preference factor, might be used to predict risky decisions. At any rate, it is a good topic for further research in this area.

APPENDIX A DATA

JUST-IMAGINE SESSION (CEV)

Probability of Winning	Subject A	B	C	D	E	F
1/8	1	1	1	2	2	1
2/8	2	1	1	2	2	1
3/8	3	4	3	3	3	4
4/8	4	5	3	5	4	6
5/8	4	3	5	4	3	6
6/8	4	4	3	2	5	5
7/8	3	5	6	4	4	4
8/8	7	5	6	6	5	1

Each number in the table is the number of times each probability was chosen for each subject.

APPENDIX A DATA

REAL GAMBLING SESSION (CEV)

Probability of Winning	Subject A	B	C	D	E	F
1/8	2	4	3	1	4	5
2/8	3	4	3	2	5	4
3/8	4	3	5	3	4	4
4/8	5	6	4	5	6	5
5/8	5	4	4	4	3	4
6/8	4	2	3	3	1	2
7/8	3	1	2	4	3	4
8/8	2	4	4	6	2	0

Each number in the table is the number of times each probability was chosen for each subject.

APPENDIX A DATA

DIFFERING EV SESSION (DEV)

Probability of Winning	Subject A	B	C	D	E	F
1/8	3	5	5	4	5	5
2/8	2	4	5	4	3	3
3/8	2	3	2	3	3	4
4/8	2	2	1	3	2	3
5/8	3	4	3	3	4	2
6/8	5	3	3	4	4	4
7/8	5	5	6	5	5	4
8/8	6	2	3	2	2	3

Each number in the table is the number of times each probability was chosen for each subject.

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Security Classification

DOCUMENT CONTROL DATA - R & D

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1. ORIGINATING ACTIVITY (Corporate author) Naval Postgraduate School Monterey, California 93940	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

The Effect of Probability Preferences in Gambling Situations

4. DESCRIPTIVE NOTES (Type of report and, inclusive dates)

Master's Thesis; June 1973

5. AUTHOR(S) (First name, middle initial, last name)

Jerry Duane Lindstrom

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
June 1973	36	11

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Naval Postgraduate School Monterey, California 93940

13. ABSTRACT

An experiment was run to examine the main factors determining choices among bets in gambling situations. In the first experiment, where all the bets had an equal expected value, a specific set of preferences among probabilities was observed. The most important of these is a preference for a 4/8 probability of winning and an avoidance of a 6/8 probability of winning. In the second experiment, where all bets had differing expected values, it was shown that both preferences for bets with higher expected values and preferences among probabilities influence subjects' choices.

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
pected Value						
pbability Preference						

Thesis
L663 Lindstrom 144230
c.1 The effect of probability preferences in gambling situations.